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FIRE MANAGEMENT RAMIFICATIONS OF HURRICANE HUGO[1]

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ABSTRACT: Hurricane Hugo passed over the Francis Marion National Forest on September 22, 1989, removing almost 75 percent of the overstory. The radically altered fuel bed presented new and formidable challenges to fire managers. Tractor-plows, the mainstay of fire suppression, were rendered ineffective. The specter of wind-driven escaped burns with no effective means of ground suppression prompted the State of South Carolina to ask for a 12-month voluntary ban on all prescribed burning in Hugo affected areas. Emergency federal funding was used to augment existing fire suppression capabilities, construct fuelbreaks, and implement a prevention campaign. The allocation of funds among various fire management activities is analyzed using the analytic hierarchy process.
KEYWORDS: Hurricane Hugo, fire management, analytical hierarchy process

INTRODUCTION

Before dawn on September 22, 1989, Hurricane Hugo came ashore just north of Charleston, SC, crossed the Francis Marion National Forest (FMNF), and left a swath of destruction that stretched clear across the State. Hurricanes are fairly common in the South, with about 120 having made landfall between Texas and Virginia since 1899 (NOAA 1977, USACE 1986). The FMNF has been subjected to hurricane-force winds about once every 16 years. But Hugo was the first category IV hurricane (maximum sustained winds of 131 to 155 mph) to strike this part of the coast during this century (Neumann et al. 1987, USACE 1986).

The consequences of Hugo on forestry, the State's third largest manufacturing industry, were dramatic. The area traversed by Hugo was heavily forested and one of the major timber producing areas of the Nation. Forest devastation from Hugo was greater than the combined damages of Hurricanes Camille (the only class V hurricane to make landfall on the U.S. this century) and Frederick, the eruption of Mount St. Helens, and the Yellowstone fires. The blowdown area encompassed 8,800 square miles, the largest from a natural disaster in U.S. history. Approximately 36 percent of the 12.2 million acres of forestland in South Carolina was damaged, and merchantable overstory loss on the 250,000 acre FMNF approached 75 percent. Total value of the timber damaged in South Carolina was estimated at over $1 billion. Sawtimber loss alone totaled 6.7 billion board feet, three times the annual harvest and enough timber to construct 660,000 homes.

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FIRE MANAGEMENT CONSIDERATIONS

The radically altered fuel complex presents new and formidable challenges to fire anagers. The enormous amount of downed timber could easily result in another isaster. Large-diameter jackstrawed fuels rendered tractor-plows, the mainstay of ire suppression in coastal South Carolina, virtually useless. With the forest canopy emoved, ground-level wind speeds will increase resulting in increased rates of fire pread. The potential for well developed convection columns coupled with the abundant irebrand material will, in turn, significantly increase the likelihood of long-range pot fires. As the debris decays, problems associated with mop-up, air quality, and isibility will increase. Reduced overstory competition and increased levels of unlight reaching the fire-prone understory will promote even more vigorous plant rowth.

Prior to Hugo, prescribed fire was the treatment of choice to suppress the nderstory and reduce the hazardous buildup of fuels on the forest floor. For example, he FMNF treated about 50,000 acres yearly (a 4- to 5-year cycle). The question of its se following Hugo was not a simple decision; many additional factors had to be onsidered. Would large charred fuels decay appreciably slower than unburned tree tems? Low intensity fires would indeed consume many of the fine fuels, but could low ireline intensities be maintained? Backing fires might keep fireline intensities at n acceptable level, but would the increased magnitude of the downward heat flux urther stress the root systems of the remaining overstory trees? Over 85 percent of he cavity trees used by red-cockaded woodpeckers (*Picoides borealis*)(a threatened and ndangered species) were destroyed (Hooper et al. 1990). The utmost care had to be aken to protect those remaining. Virtually any fire would destroy the pine seed crop, ny new germinants (longleaf pine [*Pinus palustris*] seed does not require a dormant eriod), and a portion of the advance regeneration. These considerations coupled with he specter of wind-driven escaped fires with no effective means of ground suppression rompted the State of South Carolina to ask for a voluntary 12-month ban on all rescribed burning in Hugo-affected areas.

How great is the threat of catastrophic fire? We searched the available iterature to see what mitigation measures and fire losses have occurred in the wake f other major U.S. hurricanes. Several category IV and one category V hurricanes have aused severe damage to forested areas in the South within the past 40 years, but none ave been followed by the catastrophic wildfires envisioned by fire managers. The otential existed, but for numerous reasons those fires that occurred did not live up o predictions and therefore were not recorded in the literature.

Hugo, like many previous hurricanes, created an untenable potential for destructive wildfire because of the dramatic increase in downed fuel loadings. Thus an inter-agency planning team was brought in to develop a wildfire hazard reduction and mitigation plan. Based on this plan which emphasized timber salvage, fire prevention, fire suppression, and fuels management (Brown et al. 1989), the Federal Emergency Management Agency (FEMA) authorized initial funding of $8.3 million for the 9-month period ending September 1990. An additional $4.2 million funded Phase II (Freeman et al. 1990) through September 1991. The USDA Forest Service earmarked $1,266,000 in FY90 and $700,000 in FY91 to address emergency fire management needs. In addition, $500,000 in Dire Emergency Act funds were distributed to 117 fire departments in the Hugo area. Thus, roughly $15 million in supplemental funds has been allocated for fire management during the first 2 years since Hugo.

The South Carolina Forestry Commission (SCFC) conducted one of the most intensive fire prevention campaigns in our Nation's history. This campaign, dubbed "GIMME 12," cost in excess of $750,000 and was a citizen-to-citizen plea to avoid outdoor burning for 12 months. The program involved direct mailings, posters, street and parade banners, and school campaigns. The hardest hit areas were saturated with television and radio advertising. T-shirts, caps, hats, and other items were given away to be used as walking reminders of the "GIMME 12" message. Personnel from the Witherbee Ranger District, FMNF, visited every church and school in the vicinity to talk about fire prevention. The fire prevention campaign heightened public awareness of the hazards of outdoor burning.

To beef up its fire management capabilities, the SCFC leased additional fire-fighting equipment and hired and trained supplemental fire personnel. Two additional detection aircraft were contracted and the flight hours of all detection aircraft were extended to increase the probability of early discovery and reporting of fires. Water-bucket equipped helicopters and two Canadian CL-215 water bombers were contracted to speed up attack time and improve suppression. Combining these aircraft with heavy bulldozers, nurse tankers, and new 4-wheel drive pickups with slip-on pumpers greatly enhanced the fire control and mop-up effectiveness of ground crews. The FMNF augmented its existing fire management forces by purchasing additional equipment and bringing in fire crews and equipment from other national forests as far away as Idaho and Montana.

The first year, fuels management focused on the construction of 20- to 30-foot wide fuelbreaks around high-risk communities and individual dwellings using FEMA funded bulldozers, trac-hoes, slashbusters, and chain saws. Approximately 2,800 miles of fuel breaks have been constructed state-wide including 300 miles of wider breaks on the FMNF. About 4,000 acres of debris have also been chipped. By the second year, many public, industrial and private landowners realized prescribed fire was the only practical long-term solution and resumed their prescribed burning programs. For example, the FMNF treated 17,000 acres during the 1990-91 dormant season.

ANALYSIS OF DECISIONS

How effective was this combined approach involving fire prevention, suppression capability and fuels management in avoiding catastrophic wildfire? It is extremely difficult, yet important, to analyze these multimillion dollar decisions. The rest of this paper provides a first step at developing a method for fire management decisionmakers to analyze such decisions.

The 1990 Spring fire season ended with a 40 percent reduction in fire occurrence statewide. No major fires occurred and only one occupied residence was lost. The CL-215's made initial attack drops on 200 fires. Table 1 shows the total fires and acres burned for 1973 through 1982 on the FMNF along with the maximum value of the Keetch-Byram drought index (Keetch and Byram 1968). The weather records for 1983 through 1989 are not archived in the national data library. On the FMNF, 1990 fire occurrence was reduced by more than 50 percent; 59 wildfires burned about 130 acres. However, the Spring 1990 fire season was abnormally wet, and the extent to which this wet period influenced the outcome cannot be determined.

Wet weather occurred again during the Spring 1991 fire season. The Wamba Ranger District had numerous incendiary fire starts but all were held to a few acres. However, a dry cold front passed over coastal South Carolina in late March bringing near-record low relative humidity. As of the April 24th situation report, the FMNF had recorded 52 wildfires that burned 2,199 acres, most of it on March 24th. During this same period the State recorded 218 wildfires that burned 1,192 acres.

'able 1. Maximum Keetch-Byram drought index, total number of fires, and acres ›urned for the Francis Marion National Forest.

YEAR	MAX. KBDI	TOTAL FIRES	TOTAL ACRES BURNED
1973	463	89	664
1974	579	121	1894
1975	411	74	683
1976	496	172	2091
1977	695	130	1028
1978	597	233	4224
1979	628	89	795
1980	617	149	2338
1981	613	264	4810
1982	415	79	1198

A cursory review of the outcome (reduced fires and acres burned) indicates an :ffective allocation of dollars. Yet, judging the quality of a decision solely by the ›utcome can be dangerous. Due to chance, good decisions can sometimes have bad ›utcomes, while bad decisions can result in good outcomes:

		Outcome	
		Good	Bad
Decision	Good	Objective	Unlucky
	Bad	Lucky	Deserving

n addition to evaluating the outcome, it is wise to look at the decision process tself. Russo and Schoemaker (1989) examine common pitfalls for decisionmakers. 'ecision trap number 10 is a failure to audit the decision process. Failure to nderstand one's decisionmaking leaves one constantly exposed to the other nine ecision traps (Russo and Schoemaker 1989). The analytical hierarchy process (AHP) Saaty 1988, 1990) can help make decisions and audit the decision process.

AHP is a method of breaking down a complex, unstructured situation into its omponent parts; arranging these parts or variables into a hierarchic order; assigning umerical values to subjective judgments on the relative importance of each variable; nd synthesizing the judgments to determine which variables have the highest priority nd should be acted upon to influence the outcome of the situation (Saaty 1988). AHP rovides a transparent decision process to make explicit, informed tradeoffs. AHP can uantify intangible, non-economic factors that so far have not been effectively ntegrated into decisionmaking. The process is particularly useful for allocating esources, planning, analyzing the impact of policy, resolving conflicts, and group ecisionmaking.

The first step in the AHP is to construct a decision model, with a goal at the top f the hierarchy, one-to-several layers of factors that are considered in the decision n the middle of the hierarchy, and the alternatives at the bottom of the hierarchy. igure 1 shows a sample decision model for fire management in the wake of Hurricane ugo. The goal is to select the mix of fire management activities that best meet fire nd resource management objectives.

Factors to consider in the decision model include the threat of catastrophic fire and the impact of fire management activities on other resources. Note that other factors like public acceptance can be modeled. The decision model and analysis presented here are meant to illustrate the process rather than to analyze it comprehensively.

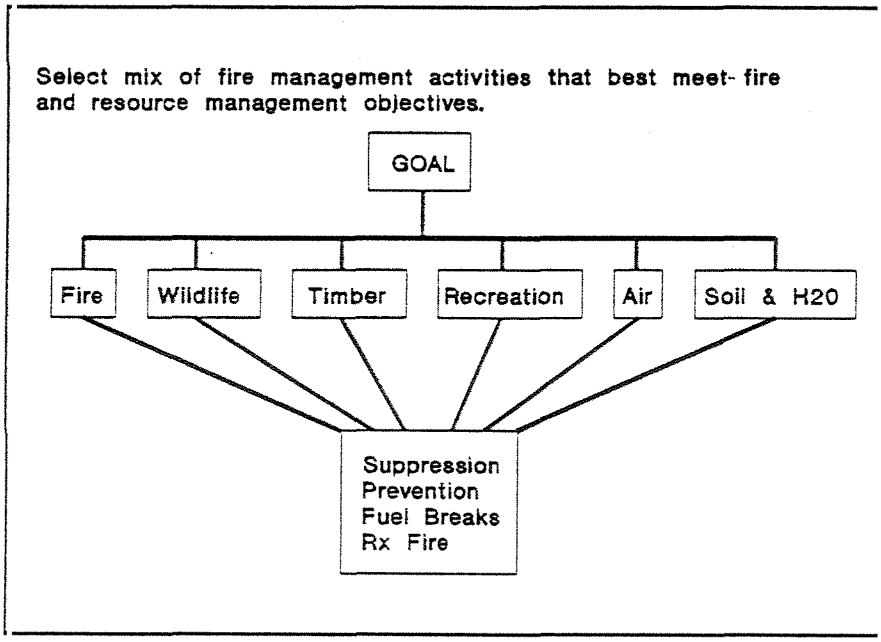

Figure 1. Simple decision model for allocating funds among fire management alternatives.

Once a hierarchical decision model is developed, exhaustive pairwise comparisons are made at each level in the hierarchy. For example, the importance of fire management objectives is compared to the importance of wildlife objectives. A nine-point sale is used from equally important (1), to moderately more important (3), to strongly more important (5), to very strongly more important (7), to extremely more important (9). Fire and timber, fire and recreation, fire and air, fire and soil and water, wildlife and timber, etc., are compared in turn. At the next level in the hierarchy, pairwise comparisons between alternatives are made in relation to meeting the various fire and resource management objectives. For example, increased suppression capability is compared to a prevention campaign for effectiveness in meeting fire objectives, wildlife objectives, timber objectives, etc. The same nine-point scale from equal to extreme is used.

To illustrate the process, a Forest Service line officer, a Forest Service fire staff officer, the authors of this paper, and a State of South Carolina fire staff officer went through the exercise of making the pairwise comparisons for the above decision model. The results are shown in Figure 2. Although we could not track the specific breakdown of expenditures, it appears that the allocation of funds mirrors the State fire staff officer's allocation.

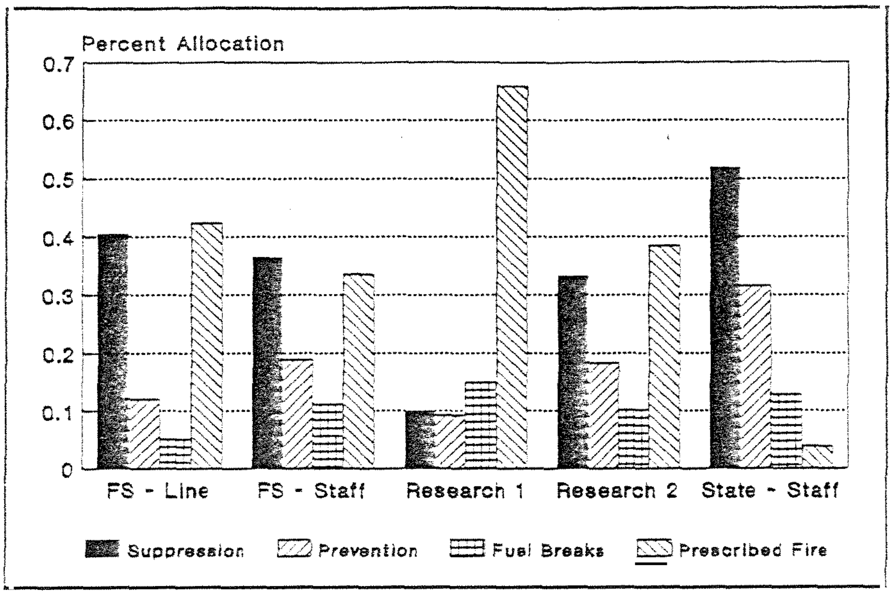

Figure 2. How a Forest Service line officer, a Forest Service fire staff officer, the authors, and a State of South Carolina fire staff officer would allocate funding among suppression capability, prevention campaign, fuel breaks, and prescribed fire; given the decision model in figure 1.

Each level in the hierarchy can be examined to explore the reasoning behind the decision. For example, Figure 3 shows the relative importance that each person placed on the various decision factors. For the state fire staff officer, the most important factor was meeting fire management objectives, followed by the effects of the alternatives on the timber resource and the air resource. The Forest Service line officer indicated that the effects on soil and water resources were the most important factor. Various people will weigh the decision factors differently according to their own values and beliefs. AHP provides a method for government decisionmakers to communicate the factors they are considering in their decisions to the public and the relative importance of each factor in the decision.

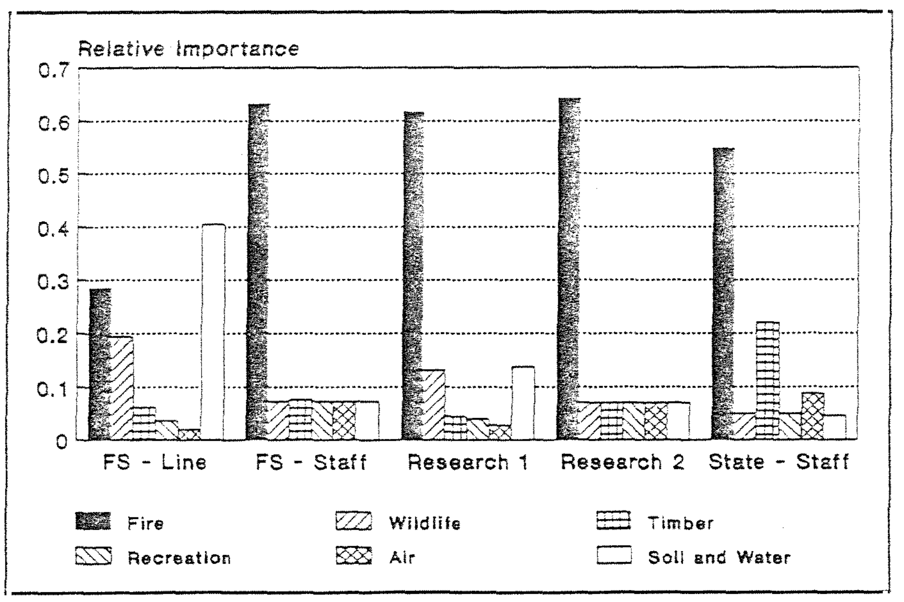

Figure 3. The relative importance of the six factors in the decision model for each individual.

A sensitivity analysis can also be performed at each level in the hierarchy. For example, for the Forest Service line officer, the effect of the fire management alternative on soil and water resources was important (0.41 from Figure 3). At 0.41, prescribed fire is slightly more important than suppression capability (Figure 4). If soil and water were increasingly important, the preference for prescribed fire would increase at the expense of suppression capability. If soil and water were judged to be less important, the preference for suppression capability would increase at the expense of prescribed fire. Changing the relative importance of soil and water would not have much effect on the relative preference of prevention and fuel breaks for the Forest Service line officer.

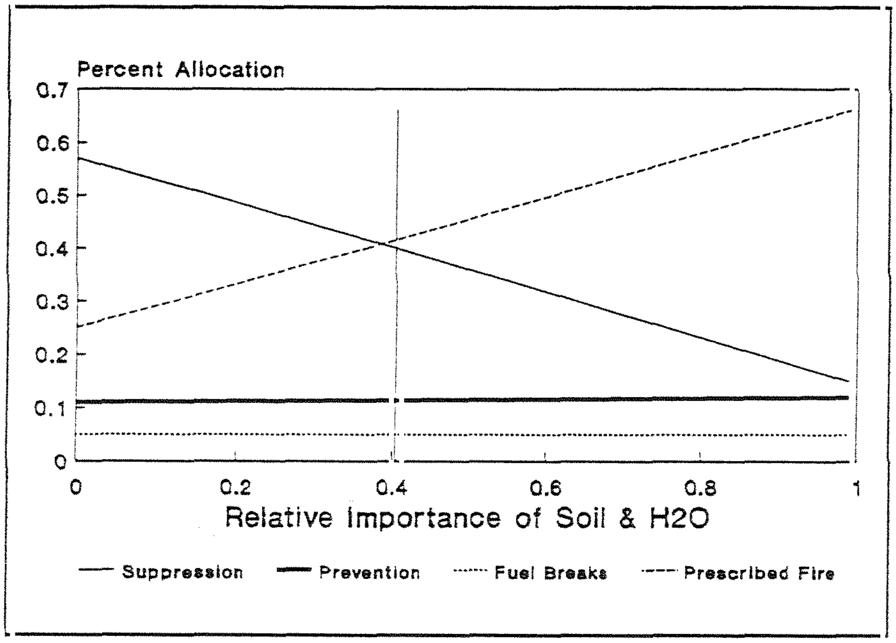

Figure 4. Sensitivity analysis for the Forest Service line officer.

In summary, because of chance, good decisions can lead to poor outcomes and poor decisions can result in favorable outcomes. In evaluating decisions, the decision process must be examined along with the outcomes. AHP provides a transparent decision process so that the reasoning behind a decision can be examined. An example of allocating funds among various fire management activities in the wake of Hurricane Hugo demonstrates the power of AHP to provide decision support and to audit the decision. The allocation of funds between suppression capability, prevention campaigns, and fuel breaks has been effective to date in alleviating the symptom of catastrophic wildfires. As the emphasis on prescribed burning increases, the disease of excessive fuel accumulation begins to be cured.

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